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CAUSES FOR VACUUM BEAD FORMATION IN PRODUCTION OF GLASS ARTICLES

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The causes of emergence of the vacuum bead in the molding of glass articles using the premolding method and the ways for its elimination are considered.

In molding wine glass stems at the Neman Glass Works using the premolding method (Fig. 1), very often a bead 2 – 4 mm in diameter emerged in the lower part of the stem (zone A). The bead was usually located at section B in the stem center, but if the mold parts adjacent to zone A had inhomogeneous temperatures, the bead was shifted from the center both in the horizontal and the vertical directions.

The glass melt produced in a continuous tank furnace did not contain visible gas inclusions. Neither were any beads formed in the glass melt in filling the mold.

The chemical composition of glass was as follows (wt.%): 58.6 SiO_2, 1.0 B_2O_3, 24.0 PbO, 1.0 ZnO, 1.9 Na_2O, 13.5 K_2O.

In manufacturing articles by the premolding method, the glass melt is displaced by the raising punch from the receiving cup into the cavity in front of the gate runner shaped as a hemisphere and from this cavity the glass melt is pushed through the gate into the mold cavity. Each subsequent glass melt portion displaces the preceding one until the mold is complete filled and a sealed contact with the article cup is accomplished.

However, if the mold is cold, the glass melt which gets to the expanded part of the stem at section B cannot be displaced in full volume by the subsequent portion, due to intense chilling, especially along the circular rim, and the resulting rapid increase in viscosity.

Therefore, the fluid glass melt passes through the central part of zone A from the beginning till the end of the molding process, while the circular rim layers contiguous to the mold metal are already solidified. This takes place, since the speed of heat propagation in the metal mold walls exceeds by an order of magnitude the speed of its propagation in glass [1].

It is known that the TCLE of glass varies significantly in solidifying, i.e., the glass in the melted state has a significantly higher TCLE than the glass in the solid state [2, 3].

While gradually becoming cooler, the central layers of the glass melt tend to shrink in volume, but this is impeded by the outer layers which are already solidified and yet are part of the integral whole with the central layers. This causes tensile stresses inside the melt, which under certain temperature differences break the inner layers which have not yet had time to consolidate; accordingly, a cavity is formed in the melt. The emerging rupture (cavity) acquires a spherical shape under the effect of surface tension forces. However, under unsteady temperature conditions, some beads of

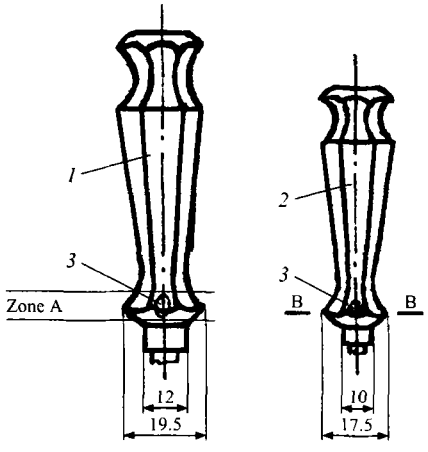

Fig. 1. Stem configuration: *1*) tall wine glass stem; *2*) wine glass stem; *3*) vacuum bead.

[1] Neman Glass Works.

nonspherical shape were registered. This was probably facilitated by the presence of microscopic gas inclusions in the glass.

To verify the assumption of this really being a vacuum bead, the articles were heat-treated in a laboratory muffle furnace at temperatures 560, 580, and 600°C for 1 h with subsequent gradual cooling. Visual inspection of the samples treated in this way indicated that at temperature 560°C, the bead significantly decreased in volume and became flat, and at 600°C the bead disappeared and only in some samples could one at a certain angle observe a slight brilliant trace looking like an internal notch.

Published sources [4] describe four factors facilitating the emergence of vacuum beads in optical glass. For the case considered, the configuration of the article made by using the premolding method should be added to the list.

The typical features of the vacuum bead for the considered case are its location, its singleness, and the spherical shape.

The frequency of its emergence was significantly decreased as a consequence of varying the molding rate and providing additional constant heating of the iron mold.

It should be noted that the vacuum bead did not appear in the stems of glasses of different design manufactured at the factory using the same technology.

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